Original Research Article

Evaluating the productivity of radish fertilized with a mixture of hairy woodrose (Merremia aegyptia L.) and carnauba straw (Copernicia prunifera)"

ABSTRACT

Aims: The use of spontaneous species present in agricultural areas is of utmost importance for farmers who cultivate in the agroecological system.

Place of Study: The experiment was conducted from June to August 2023 at the Rafael Fernandes experimental farm, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, with the aim of evaluating the In study the productivity of radish fertilized with a mixture of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*).

Study Design and Methodology: The treatments consisted of five amounts of a mixture of hairy woodrose with carnauba straw (0.0; 1.2; 2.4; 3.6 and 4.8 kg m^{-2} of area). The spacing used was 0.2 x 0.1 m, with a pit^{-1} plant. The total area of the plot was 1.1 x 0.6 m, corresponding to 0.66 m^{-2}, with a useful area of 0.42 m^{-2}, consisting of twenty plants.

Agronomic characteristics of radish (*Raphanus sativus* L.): plant height; root diameter; productivity of the area plus root; root weight and total dry mass and root dry mass.

Conclusions: The amount of 4.5 kg m^{-2} of the mixture of hairy woodrose plus carnauba straw was what promoted the greatest increase with a maximum value of 1626.66 g m^{-2} for the aerial part plus root characteristic. The use of a mixture of fertilizers of plant origin is promising for the development of radish in the Mossoró-RN region, Brazil.

Keywords: Agroecological production; semiarid species, root vegetables.

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1. INTRODUCTION

Radish (*Raphanus sativus* L.) is a tuberous root from the Brassicaceae family, originating from the Mediterranean region, highly appreciated for its spicy flavor and crunchy pulp, which, in ancient Egypt, Assyria, Greece and Rome, was a widely consumed vegetable [1]. For [2] and [3] the cultivars that have greater market acceptance are those that produce roots with a spicy flavor, in addition to having a globular shape and reddish color.

It is characterized as one of the shortest cycle crops among vegetables, with harvest taking place from 25 to 30 days after sowing, which makes it a good option for rural producers [4].

Vegetables generally react well to organic fertilizers, both in terms of productivity and the quality of the products obtained [5]. Therefore, organic fertilization is a great example of management that is being widely used by the agroecological system, since it often seeks to make use of alternative materials that generate reductions in production costs, at the same time without causing damage to the environment. environment. Its adoption, in addition to being a way of providing healthier organic products, can correct possible deficiencies of

macro and micronutrients in the soil, such as nitrogen, phosphorus, potassium, calcium, magnesium [6].

Among the promising species within the herbaceous extract of the caatinga, there is hairy woodrose (*Merremia aegyptia* L.) with production of green and dry phytomass of the order of 40000 and 6000 kg ha^{-1}, respectively and nitrogen content of 24.7 g kg^{-1} and carbon nitrogen ratio of 17.2 at 104 days after emergence, being used as green fertilizer in vegetables [7]. Another species that presents characteristics in terms of phytomass availability and nitrogen concentration above 15 g kg^{-1} is carnauba straw (*Copernicia prunifera*), which is widely present in agricultural areas in the region of Mossoró, RN [8].

Several studies have been carried out on vegetables using these species: arugula [9]; [10]; [11]; [12]; lettuce [13]; [14]; coriander [15].

Given the importance of studying species present within agroecological vegetable production areas, the objective was to evaluate the productivity of radish fertilized with a mixture of hairy woodrose and carnauba straw.

MATERIAL AND METHODS

CHARACTERIZATION OF THE EXPERIMENTAL AREA

The experiment was carried out at the Rafael Fernanades Experimental Farm in Alagoinha from June to August 2023, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, which has around 400 hectares [16], on soil classified as Argissolic Red Yellow Latosol sandy loam [17].

Before setting up the experiment, soil samples were taken at a depth of 0-20 cm, which were air-dried and sieved through a 2 mm mesh and subsequently analyzed at the Soil Chemistry and Fertility Laboratory at UFERSA. The results were as follows: pH (water 1:2.5) = 6.5; Ca = 2.2 cmol dm^{-3}; Mg = 0.8 cmolc dm^{-3}; K = 25.0 mg dm^{-3}; Na = 1.2 mg dm^{-3}; P = 26.8 mg dm^{-3} and M.O. = 0.6 g kg^{-1}.

The pH was determined in suspension with 10 ml of soil, 10 ml of deionized water and 5 ml of buffer solution as described; Phosphorus (P) content: determined using the molybdenum blue spectrophotometry method, using the nitric digestion process in a system closed using the microwave oven as a heat source; Calcium (Ca) and magnesium (Mg) contents: determined through atomic absorption, using the atomic sulfuric acid digestion method; Potassium content (K): determined by the emission photometry method flame and

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Nitrogen content (N): was determined in part of the acid digestate sulfuric acid, by the Kjeldahl method [18]

EXPERIMENTAL DESIGN AND TREATMENTS

The experiment was conducted in randomized complete blocks with five treatments and four replications. The treatments consisted of five amounts of a mixture of hairy woodrose with carnauba straw (0.0; 1.2; 2.4; 3.6 and 4.8 kg m^{-2} of area). The spacing used was 0.2 x 0.1 m with a pit^{-1} plant. The total area of the plot was 1.1 x 0.6 m, corresponding to 0.66 m^{-2}, with a useful area of 0.42 m^{-2}, consisting of twenty plants. The proportion was used of 60% hairy woodrose plus 40% carnauba straw was used, following the recommendation of [19].

Daily irrigations were carried out (morning and afternoon) in order to maintain the soil at field capacity for the full development of the crop. Cultural treatments were carried out (removal of invasive plants) preventing competition for water and nutrients with the radish crop. No chemical pesticides were used to control undesirable plants, and control was carried out manually.

"To compose the mixture of fertilizers in the research, hairy woodrose (*Merremia aegyptia* L.) was used, a spontaneous species from the semi-arid region with production of green and dry phytomass of the order of 42000 kg ha^{-1} and 6000 kg ha^{-1}, respectively, with nitrogen content of 24.7 g kg^{-1} at 104 days after emergence" [20].

The hairy woodrose was harvested in a vegetation area next to the experimental area 120 days after emergence, being crushed with a manual tool (machete) and incorporated into the soil together with the carnauba straw. Samples were taken and sent to the soil fertility and plant nutrition laboratory at the UFERSA Agricultural Sciences Center for carbon (C) analysis; nitrogen (N); phosphorus (P); potassium (K^+); calcium (Ca^{2+}); magnesium (Mg^{2+}) and carbon/nitrogen ratio, whose values were: 535 g kg^{-1} C, 23.5 g kg^{-1} N, 10.8 g kg^{-1} P, 15.4 g kg^{-1} K^+, 9, 7 g kg^{-1} Ca^{2+}, 11.7 g kg^{-1} Mg^{2+} and a nitrogen/carbon ratio of 23/1 (Figure 1A).

The following methodology was used to determine macronutrient levels: Phosphorus (P) content: determined using the molybdenum blue spectrophotometry method, using the nitric digestion process in a system closed using the microwave oven as a heat source; Calcium (Ca) and magnesium (Mg) contents: determined through atomic absorption, using the atomic sulfuric acid digestion method; Potassium content (K): determined by the emission photometry method flame and Nitrogen content (N): was determined in part of the acid digestate sulfuric acid, by the Kjeldahl method [21]

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Carnauba straw was collected on the experimental farm Fazenda Rafael Fernandes. When the experiment was set up, five straw samples were taken and sent to the soil fertility and plant nutrition laboratory of the Department of Environmental and Technological Sciences at UFERSA, for carbon (C) analysis; nitrogen (N); phosphorus (P); potassium (K^{+}); calcium (Ca^{2+}); magnesium (Mg^{2+}) and carbon/nitrogen ratio. It presented the following results: 460 g kg^{-1} C; 16.0 g kg^{-1} N; 10.3 g kg^{-1} P; 8.0 g kg^{-1} K; 9.0 g kg^{-1} Ca; 8.6 g kg^{-1} Mg and carbon/nitrogen ratio (29/1), quantified as a function of dry matter, taking into account 10% moisture, being incorporated in the 0 – 20 cm layer of the soil. The material remained for an incorporation period of thirty days, prior to planting (Figure 1B).

A	B

Figura 1. The hairy woodrose species (*Merremia aegyptia* L.) in full bloom in the semi-arid region, within the UFERSA campus (A) and carnauba straw (B) on the experimental farm. **Photo:** (A) Researcher PhD, Leader of the Hairy woodrose research group, Paulo César Ferreira Linhares. (B) Agronomy student and member of the hairy woodrose research group, Maria Elisa da Costa Souza.

"The fertilizers were mixed and applied to the soil depending on the quantities and forms of application to the soil, with the material remaining for an incubation period of thirty days before planting. During the process of decomposition of the mixture of hairy woodrose and poultry manure in the soil, irrigation was carried out on all plots up to field capacity, being of fundamental importance in the nitrification process" [22].

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MEASUREMENT OF AGRONOMIC CHARACTERISTICS OF RADISH

Thirty days after sowing, the crop was harvested, where the plants were transported to the Vegetable Post-Harvest Laboratory of the Department of Agronomic and Forestry Sciences at UFERSA, where the following characteristics were analyzed: plant height (performed with a sample of fifteen plants per plot, measured the height from the base to the

apex of the plant using a millimeter ruler and expressed in cm plant^{-1}); Root diameter (five roots were used, measured using a caliper, expressed in mm); productivity of the area plus root (measured by the weight of all plants in the useful area of the plot, expressed in g m^{-2} of area); root weight (determined by weight of all roots, expressed in g m^{-2}) and total dry mass and dry mass of the root (Samples were weighed on a 1.0 g precision scale, followed by drying in a forced air heating oven at 65 °C, until constant mass).

STATISTICAL ANALYSIS

Statistical analysis was carried out according to conventional methods of analysis of variance [23], using the statistical software ESTAT [24]. The response curve adjustment procedure was performed with the ESTAT software.

RESULTS AND DISCUSSION

A statistical difference was observed for all characteristics evaluated at the level of P<0.01 probability depending on the different amounts of hairy woodrose plus carnauba straw (Table 1). This probably demonstrates the efficiency of mixing fertilizers (hairy woodrose plus carnauba straw) in promoting greater nutrient availability, in addition to providing better soil conditions, such as moisture retention, thus promoting better development of the radish crop.

Table 1. Plant height, expressed in cm plant^{-1} (PH), root diameter, expressed in mm (RD), weight of the area + root part, expressed in g m^{-2} of area (PT), root weight, expressed in g m^{-2} area (PR), total dry mass, expressed in g m area (DMT) and root dry mass, expressed in g m area (DMR) of radish under green manure with hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*).

Causes of Variation	GL	AT	DR	PT	PR	MST	MSR
Treatments	4	8.55**	8.47**	22.27**	18.32**	16.57**	10.05**
Blocks	3	7.21**	5.61*	9.50**	9.66**	3.12^{ns}	3.02^{ns}
Residue	12	------	------	-------	-------	-------	------
Average	----	11.93	32.27	1339.95	999.89	94.68	58.73
CV (%)	----	9.9	5.7	10.7	12.2	11.4	13.9

** Significant at 1% probability; * Significant at 5% if probability and ns not significant.

For plant height, there was an increase of 4.23 cm plant^{-1} due to the greater quantity (4.8 kg) in relation to the absence of fertilization (0.0 kg) with a maximum value of 14.05 cm plant^{-1} (Figure 2). Plant height is a characteristic greatly influence by the availability of

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nitrogen in the soil, which was probably what occurred when green manure was applied with hairy woodrose plus carnauba straw. [25] studying the organic cultivation of radish fertilized with hairy woodrose (*Merremia aegyptia* L.) in the absence and presence of bovine manure with a maximum height of 10.7 cm plant^{-1} lower than the present study. This inferiority is probably due to the smaller amounts of hairy woodrose used in the experiment. [26], studying the response of red radish "SAXA"-220" in function of different proportions of cattle manure under different cultivation environments, found a plant height of 18.51 cm plant^{-1}, a value higher than that of the aforementioned research. This superiority is probably due to the larger amounts of cattle manure used.

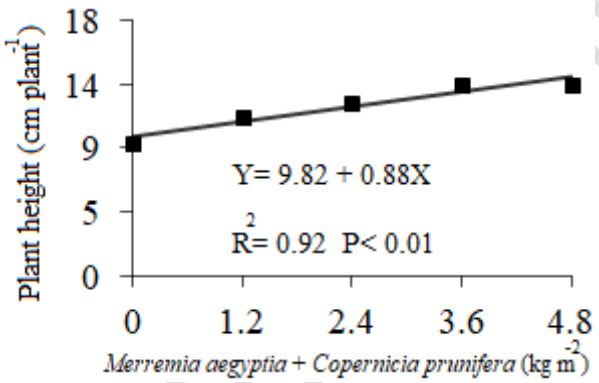

Figure 2. Height of radish plant depending on different amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) incorporated into the soil.

The amount of 4.8 kg m^{-2} of area was the one that promoted the largest radish diameter, with a maximum value of 35.51 mm (Figure 3), a value corresponding to 22.4% in relation to the treatment without fertilization. [27], evaluating the optimization of the best quantity of hairy woodrose in radish production, found a value of 4.12 cm plant^{-1}, equivalent to 412 mm, a value higher than that of the aforementioned research. Diameter is an important characteristic, as it is related to the appearance of the vegetable, influencing its commercialization. [28], studying the evaluation of different dosages of vermicompost produced from fruits and vegetables in the production of radish (*Raphanus sativus* L.), found a root diameter of 28.4 mm with the use of soil plus FLV vermicompost, a value lower than that of the present study. This inferiority to the present study is probably due to the nutritional quality of the vermicompost.

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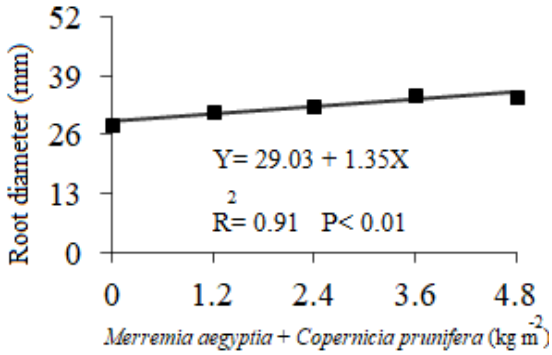

Figure 3. Radish root diameter depending on different amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) incorporated into the soil.

For the variable weight of the shoot plus root, there was an increase of 797.74 g m^{-2} between the smallest quantity (0.0 kg m^{-2}) and the largest (4.5 kg m^{-2}), with a maximum value of 1626.66 g m^{-2} in the amount of 4.5 kg m^{-2} of the hairy woodrose mixture with carnauba straw (Figure 4A) and 1092.89 g m^{-2} for root weight in the amount of 4.3 kg m of the hairy woodrose mixture plus carnauba straw (Figure 4B). This characteristic is important for those who work in the production of vegetable crops, considering that the aerial part plus the root is used in commercialization. [29], studying the residual effect of pasture killing on the productive performance of radish, found productivity of 10850 kg ha^{-1}, equivalent to 1085 g m^{-2}, a value lower than that of the aforementioned research. Just like, [30], evaluating the optimization of the best quantity of hairy woodrose in radish production, found a value of 1380 g m^{-2}. [31], studying the response of red radish "SAXA"-220" in function of different proportions of cattle manure under different cultivation environments, with productivity of 5.9 t ha^{-1}, equivalent to 590g m^{-2}, a value lower than that of the present study. This inferiority is probably due to the lower efficiency of the amounts of cattle manure in promoting soil improvements, for greater absorption of nutrients by plants.

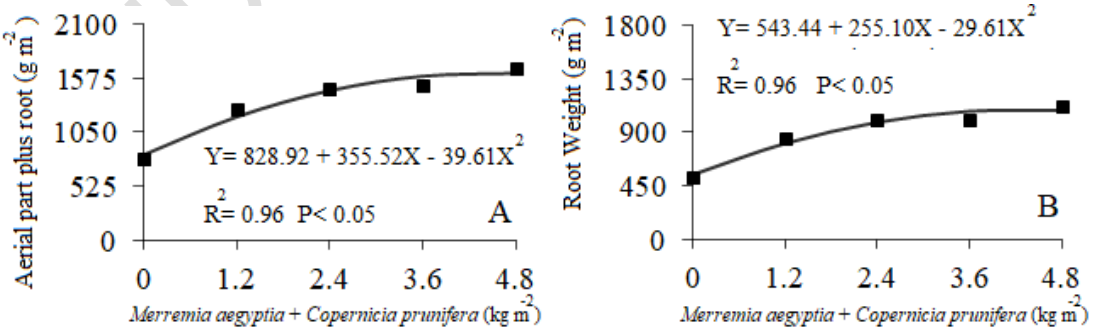

Figure 4. Aerial part plus root (A) and root weight (B) of radish depending on different amounts of the hairy woodrose (*Merremia aegyptia* L.) mixture plus carnauba straw (*Copernicia prunifera*) incorporated into the soil.

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In total dry mass, there was an increase of 50.86 g m^{-2} between the lowest dose (0.0 kg m^{-2}) and the dose (4.0 kg m^{-2}) of the mixture of hairy woodrose and carnauba straw, with a value maximum of 112.1 g m^{-2} (Figure 5A). For the dry mass of the root, it obtained maximum production, with a value of 68.79 g m^{-2} in the quantity 3.8 kg m^{-2}, reaching an increase of 28.05 g m^{-2} between the lowest dose (0.0 kg m^{-2}) the largest (3.8 kg m^{-2}) of the mixture of hairy woodrose and carnauba straw (Figure 5B).These are important characteristics, as they measure the quantity of economically important substances, indicating the quality, productivity and growth of these roots.

[32], evaluating the microbiological attributes of the soil and radish productivity influenced by the use of spontaneous species, found a maximum value of the variable root dry mass (1.07 g $plant^{-1}$) at a dose of 17.30 t ha^{-1}, equivalent to 1.73 kg m^{-2}. [33], evaluating the agronomic performance of radish fertilized with *Calotropis procera* (Ait.) R. Br. in two growing seasons, they obtained an increase of 0.5 g $plant^{-1}$ of dry mass of radish roots in relation to the smaller amount of *Calotropis procera* (5.4 t ha^{-1}, corresponding to 0.54 kg m^{-2}), presenting a maximum value of 15.6 t ha^{-1}, which is equivalent to 1.56 kg m^{-2}.

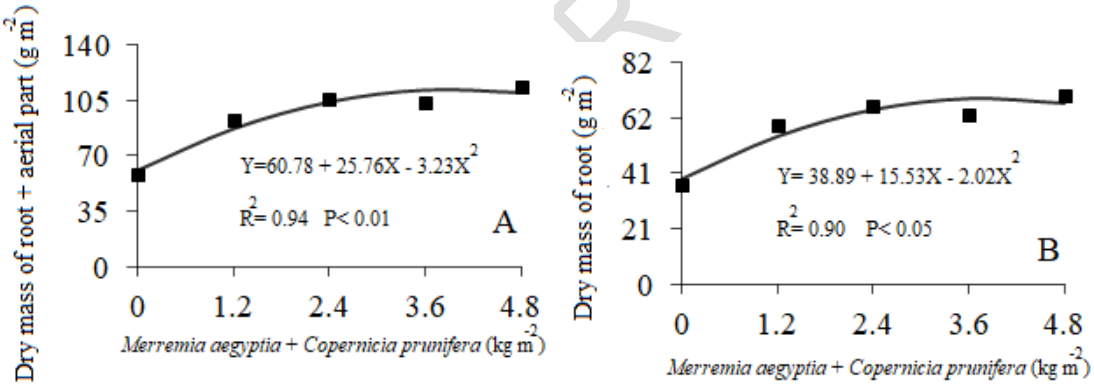

Figure 5. Dry mass of root plus aerial part (A) and dry mass of root (B) of radish depending on different amounts of the hairy woodrose (*Merremia aegyptia* L.) mixture plus carnauba straw (*Copernicia prunifera*) incorporated into the soil.

CONCLUSION

The amount of 4.5 kg m^{-2} of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*) was what promoted the greatest increase with a maximum value of 1626.66 g m^{-2} for the aerial part plus root characteristic.

The use of a mixture of fertilizers of plant origin (hairy woodrose + carnauba straw) is promising for the development of radish in the Mossoró-RN region, Brazil.

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